

1999 Fuel Cells GRC Army Research Office Grant No. DAAD19-99-1-0271

Abstract Report

The first GRC on Fuel Cells originated from interest expressed jointly by industry, national laboratories and academia. While there are many meetings organized by interested parties and/or for profit sponsors, a critical, impartial forum for open discussion was lacking. The subject has spread in the last few years with ever increasing rapidity. As of now several of the biggest industrial corporations and research institutions all over the globe have begun or augmented research efforts on the subject. Also, with the express support from Government granting agencies interested in furthering the subject, research funds have spurred a large body of academic work. The intent was to gather under one umbrella in a focused manner researchers from different fields whose work is very relevant to the subject matter. The multifarious topics covered the gamut from the very fundamental to the practical with presentations by the foremost authorities in Fuel Cells science and technology. All the presentations were followed by spirited discussions. The GRC management has approved yearly continuation of the Fuel Cell Conferences.

Appendix

The Co-Chairs were **Shimshon Gottesfeld**, Los Alamos Natl. Lab. And **Mordecai Shelef**, Ford Scientific Research Laboratory.

The topics presented included:

J. Turner, NREL, US, Hydrogen Production from Water and Sunlight via Photoelectrolysis; **E. Greenbaum**, ORNL, US, Renewable Hydrogen and Oxygen Production by Photosynthetic Water Splitting; **P. N. Ross**, LBNL, US, The Skin-Effect in the Electrocatalytic Properties of Certain Binary Alloys; **S. Mukherjee**, Northeastern Univ., US, Electrocatalysis at Nano-Phase Cluster Interfaces: A Molecular Level Perspective; **M. Watanabe**, Yamanashi University, Japan, Design and catalysis mechanisms of Pt alloy catalysts for CO tolerant anodes and high performance cathodes in PEFC's; **A. Wieckowski**, University of Illinois, US, Platinum/Ruthenium Methanol Oxidation Electrocatalysis: Structure/Function Relationships; **K. Colbow**, Ballard, Canada, In-Situ Characterization of Direct Methanol Fuel Cells and Stacks under Practical Operating Conditions; **K-D. Kreuer**, Max Planck Institute, Stuttgart, Germany, On the Way to New Membrane Materials for Hydrogen and Methanol FC's; **M. Pineri**, France, Sulfonated polyimide membranes for polymer electrolyte fuel cells; **P. Pintauro**, Tulane University, US, Polyphosphazene-Based Proton-Exchange Membranes for Direct Methanol Fuel Cells; **T. Zawodzinski**, Los Alamos National Laboratory, US, The Membrane/Electrode Assembly and "Practical Electrocatalysis" in the Fuel Cell; **W. Schnurnberger**, DLR, Germany, Current Distribution and Transient Response in PEFC Stacks; **W. Worrell**, U. Penn., US, Current Trends in Planar SOFC Research and Development; **S. Singhal**, Siemens- Westinghouse, US, Recent Progress in Solid Oxide Fuel Cells; **U. Stimming**, Technical University Munich, Germany, Concepts of SOFC co-generation power plants for the kW to MW range;

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Richard Bellow/Paul Berlowitz, Exxon, US, Hydrocarbon Fuel Processors - Development Issues in Fuel Cell Vehicle Applications; **H. Gasteiger**, Opel, Germany Selective Oxidation of CO in H₂-Rich Gas: Mechanistic Aspects and Process Optimization; **Manfred Waidhas**, Siemens, Germany, PEM Fuel Cells for Mobile and Decentralized Applications - System and Component Aspects; **Romesh Kumar**, ANL, US, Design Considerations for a Gasoline-Fueled Automotive Fuel Cell System; **R.M. Moore**, UC Davis, US, Comparative Evaluation of Fuel Cell Power Systems for Transportation.

Gordon Research Conference on

Fuel Cells

Plymouth State College
Plymouth, New Hampshire, USA
June 27-July 2, 1999

Co-Chairs

Shimshon Gottesfeld (*Los Alamos National Lab*)
Mordecai Shelef (*Ford Scientific Research Laboratory*)

Fuel cells is an area of scientific research that presently merits a Gordon Conference unto itself. This research is related to challenging scientific problems in areas of materials science, interfacial science, transport phenomena, electrocatalysis and heterogeneous catalysis. Subjects at the frontier of the field are:

- preparation of multilayered thin film structures with effective interfacial characteristics
- heterogeneous catalysis at low temperature under adverse conditions of severe surface contamination
- subtle effects of metal particle size and metal crystal structure on electrocatalysis in the nanometer range of particle sizes
- heterogeneous catalysis in non-steady state systems for the reforming of liquid fuels to hydrogen
- transport phenomena in complex materials including ion conducting membranes and porous layers of mixed hydrophilic/hydrophobic surface characteristics
- water interaction with polymeric surfaces, and more.

The relevance is almost self evident. The subject has spread in the last few years with ever increasing rapidity. As of now several of the biggest industrial corporations and research institutions all over the globe have begun or augmented research efforts on the subject. Among these are the American, German, Japanese and other automotive companies (GM, Ford, Chrysler, Toyota, Daimler Benz, BMW, Mazda, Fiat and several others); energy companies (Mobil, Amoco, Shell); equipment companies (Siemens, ABB, Alsthom, United Technologies, Westinghouse, Ballard); government laboratories (Los Alamos, Lawrence Berkeley, Argonne), contract laboratories (SRI, ADL). With the support from Government granting agencies (DOE, DARPA, NSF) interested in furthering the subject, research funds have spurred academic work. It is a conference that will contribute to reversing the prevailing trend of decreasing participation of industrial scientists in GCR.

Sunday Night: Fuel Generation from Renewable Resources

Session Chair: **Ross Lemons**, *LANL*

- **J. Turner**, *NREL, US*
Hydrogen Production from Water and Sunlight via Photoelectrolysis

- **E. Greenbaum, ORNL, US**
Renewable Hydrogen and Oxygen Production by Photosynthetic Water Splitting

Monday Morning: Electrocatalysis

Session Chair: **Eric Stuve, Univ. of Washington**

- **P. N. Ross, LBNL, US**
The Skin-Effect in the Electrocatalytic Properties of Certain Binary Alloys
- **S. Mukherjee, Northeastern Univ., US**
Electrocatalysis at Nano-Phase Cluster Interfaces: A Molecular Level Perspective
- **M. Watanabe, Yamanashi University, Japan**
Design and catalysis mechanisms of Pt alloy catalysts for CO tolerant anodes and high performance cathodes in PEFCs

Monday Night : Electrocatalysis & Direct Methanol Fuel Cells

Session Chair: **S.R. Narayanan, JPL**

- **A. Wieckowski, Urbana, US**
Platinum/Ruthenium Methanol Oxidation Electrocatalysis: Structure/Function Relationships
- **K. Colbow, Ballard**
In-Situ Characterization of Direct Methanol Fuel Cells and Stacks under Practical Operating Conditions

Tuesday Morning: The Ionomeric Membrane

Session Chair: **Robert Savinell, Case Western Reserve Univ.**

- **K-D. Kreuer, Max Planck Institute, Stuttgart, Germany**
On the Way to New Membrane Materials for Hydrogen and Methanol FCs
- **M. Pineri, France**
Sulfonated polyimide membranes for polymer electrolyte fuel cells
- **P. Pintauro, Tulane University, US**
Polyphosphazene-Based Proton-Exchange Membranes for Direct Methanol Fuel Cells

Tuesday Night: Membrane/electrode Assemblies & Cells

Chair: **Don Maricle, Maricle Consulting, US**

- **T. Zawodzinski, Los Alamos National Laboratory, US**
The Membrane/Electrode Assembly and "Practical Electrocatalysis" in the Fuel Cell
- **W. Schnurnberger, DLR, Germany**
Current Distribution and Transient Response in PEFC Stacks

Wednesday Morning: Solid Oxide Fuel Cells

Chair: **Scott Barnett, Northwestern Univ.**

- **W. Worrell, U. Penn., US**
Current Trends in Planar SOFC Research and Development
- **S. Singhal, Siemens-Westinghouse, US**
Recent Progress in Solid Oxide Fuel Cells
- **U. Stimming, Technical University Munich, Germany**
Concepts of SOFC co-generation power plants for the kW to MW range

Wednesday Night: Fuel Processing: Liquid Fuels to Hydrogen

Chair: **Wayne Goodman**, *Texas A & M Univ.*

- **Richard Bellow/Paul Berlowitz**, *Exxon*
Hydrocarbon Fuel Processors - Development Issues in Fuel Cell Vehicle Applications
- **H. Gasteiger**, *Opel, Germany*
Selective Oxidation of CO in H₂-Rich Gas: Mechanistic Aspects and Process Optimization

Thursday Morning : The Fuel Cell Stack and Power System

Chair: **Jim Adams**, *Ford Motor Company*

- **Manfred Waidhas**, *Siemens, Germany*
PEM Fuel Cells for Mobile and Decentralized Applications - System and Component Aspects
- **Romesh Kumar**, *ANL*
Design Considerations for a Gasoline-Fueled Automotive Fuel Cell System
- **R.M. Moore**, *UC Davis, CA*
Comparative Evaluation of Fuel Cell Power Systems for Transportation

Thursday Night: Plenary Lecture and General Discussion

- **Paul MacCready**, *AeroVironment, CA, US*



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FUEL CELLS

Plymouth State College, Plymouth, NH
(27-Jun-99) - (02-Jul-99)

This was the final registration list for the 1999 Conference on
FUEL CELLS.

<u>JAMES A ADAMS</u>	FORD MOTOR COMPANY	Discussion Leader	Registered
<u>KESHA VARAJA ALIVE</u>	UNITED CATALYSTS INC.	Attendee	Registered
<u>TIMOTHY R ARMSTRONG</u>	PACIFIC NORTHWEST NATIONAL LABORATORY	Attendee	Registered
<u>JENNIE R ATKINS</u>	CLEMSON UNIVERSITY	Poster Presenter	Registered
<u>NEIL AVERY</u>	CSIRO	Attendee	Registered
<u>BAMDAD BAHAR</u>	W.L. GORE & ASSOCIATES, INC.	Attendee	Registered
<u>SCOTT A BARNETT</u>	NORTHWESTERN UNIVERSITY	Discussion Leader	Registered
<u>RICHARD J BELLOW</u>	INTERNATIONAL FUEL CELLS	Speaker	Registered
<u>STEVEN H BERGENS</u>	UNIVERSITY OF ALBERTA	Poster Presenter	Registered
<u>RUSSELL R BESSETTE</u>	UMASS-DARTMOUTH	Attendee	Registered
<u>MICHAEL J BINDER</u>	US ARMY CORPS OF ENGINEERS RSCH LAB	Attendee	Registered
<u>CHRISTOPHER J BROOKS</u>	HONDA R&D AMERICAS	Attendee	Registered
<u>SCOTT A CALABRESE BARTON</u>	COLUMBIA UNIVERSITY	Poster Presenter	Registered
<u>RICHARD T CARLIN</u>	OFFICE OF NAVAL RESEARCH	Attendee	Registered
<u>DAVID J CARLSSON</u>	NATIONAL RESEARCH COUNCIL OF CANADA	Attendee	Registered
<u>LEA D CHEN</u>	UNIVERSITY OF IOWA	Attendee	Registered
<u>CALUM R CHISHOLM</u>	CALTECH MATERIALS SCIENCE DEPARTMENT	Poster Presenter	Registered
<u>SIMON J CLEGHORN</u>	W L GORE AND ASSOCIATES	Attendee	Registered
<u>KEVIN M COLBOW</u>	BALLARD POWER SYSTEMS	Speaker	Registered
<u>ALAIN COTE</u>	IREQ/ HYDRO-QUEBEC	Attendee	Registered
<u>STEPHEN E CREAGER</u>	CLEMSON UNIVERSITY	Attendee	Registered
<u>EMORY S DE CASTRO</u>	E-TEK INC.	Attendee	Registered
<u>ATSUSHI DEMACHI</u>	HONDA ENGINEERING CO LTD	Attendee	Registered
<u>LAWRENCE DEVRIES</u>	UNIVERSITY OF UTAH	Monitor	Registered
<u>HUYEN N DINH</u>	LOS ALAMOS NATIONAL LABORATORY	Attendee	Registered
<u>ANDREAS DOCTER</u>	DAIMLER CHRYSLER AG	Attendee	Registered
<u>TAKAYOSHI DOI</u>	TMMNA	Attendee	Registered
<u>MICHAEL EIKERLING</u>	RESEARCH CENTER JUELICH GMBH	Poster Presenter	Registered
<u>HANNA ERICSON</u>	CHALMERS UNIVERSITY OF TECHNOLOGY	Poster Presenter	Registered
<u>PETER W FAGUY</u>	UNIVERSITY OF LOUISVILLE	Poster Presenter	Registered
<u>PETER S FEDKIW</u>	U.S. ARMY RESEARCH OFFICE, CHEMICAL SCIENCES DIV	Attendee	Registered
<u>HUBERT A GASTEIGER</u>	GLOBAL ALTERNATIVE PROPULSION CENTER	Speaker	Registered
<u>HOSSEIN GHEZEL-AYAGH</u>	ENERGY RESEARCH CORPORATION	Attendee	Registered
<u>SASHA GORER</u>	SYMIX	Poster Presenter	Registered
<u>RAYMOND GORTE</u>	UNIVERSITY OF PENNSYLVANIA	Poster Presenter	Registered
<u>SHIMSHON GOTTESFELD</u>	LOS ALAMOS NATIONAL LABORATORY	Chair	Registered
<u>ELIAS GREENBAUM</u>	OAK RIDGE NATIONAL LAB	Speaker	Registered
<u>STEVEN J HAMROCK</u>	3M	Attendee	Registered
<u>KEVIN W HATHCOCK</u>	COLUMBIAN CHEMICALS COMPANY	Attendee	Registered
<u>JYOTSNA IYER</u>	ELFATO CHEM NORTH AMERICA, INCORPORATED	Attendee	Registered
<u>CRAIG P JACOBSON</u>	LAWRENCE BERKELEY NATL LABORATORY	Attendee	Registered
<u>LUDWIG JOERISSEN</u>	ZSW	Poster Presenter	Registered
<u>HYUK-NYUN KIM</u>	LG CHEMICAL LTD	Attendee	Registered
<u>KWANG S KIM</u>	GINER, INCORPORATED	Attendee	Registered
<u>JEFFREY KOLDE</u>	W.L. GORE & ASSOCIATES INC	Attendee	Registered
<u>ROBERT F KOVAR</u>	FOSTER-MILLER, INC.	Attendee	Registered

<u>KRAUS D KREUER</u>	MAX-PLANCK-INSTITUT FKf	Speaker	Registered
<u>ANTHONY R KUCERNAK</u>	IMPERIAL COLLEGE OF SCIENCE	Poster Presenter	Registered
<u>ROMESH KUMAR</u>	ARGONNE NATIONAL LABORATORY	Speaker	Registered
<u>SRIDHAR M KUMAR</u>	E.I. DUPONT	Attendee	Registered
<u>H RUSSELL KUNZ</u>	UNIVERSITY OF CONNECTICUT	Attendee	Registered
<u>RENE B LAPIERRE</u>	MOBIL TECHNOLOGY COMPANY	Attendee	Registered
<u>JOSEPH T LEE</u>	ONTARIO POWER TECHNOLOGIES	Attendee	Registered
<u>CHRISTOPHER LEE</u>	UNIVERSITY OF ALBERTA	Attendee	Registered
<u>ROSS LEMONS</u>	LOS ALAMOS NATIONAL LABORATORY	Discussion Leader	Registered
<u>MORTON LITT</u>	CASE WESTERN RESERVE UNIVERSITY	Poster Presenter	Registered
<u>DI-JIA LIU</u>	ALLIED SIGNAL RESEARCH & TECHNOLOGY	Attendee	Registered
<u>TE-YANG LIU</u>	DELTA F CORP	Attendee	Registered
<u>ROBERT E LOWREY</u>	UNIVERSITY OF FLORIDA	Poster Presenter	Registered
<u>SERGUEI LVOV</u>	PENN STATE UNIVERSITY	Attendee	Registered
<u>CORMAC H LYONS</u>	NATIONAL POWER	Attendee	Registered
<u>DONALD MACARTHUR</u>	CHEMAC	Attendee	Registered
<u>PAUL B MACCREADY</u>	AERO VIRONMENT, INC.	Speaker	Registered
<u>ROBERT C MAKKUS</u>	NETHERLANDS ENERGY RESEARCH FOUNDATION	Attendee	Registered
<u>STEPHANIE MANIGUET</u>	UNIVERSITY OF SOUTHAMPTON	Poster Presenter	Registered
<u>DONALD L MARICLE</u>	MARICLE CONSULTING, LLC	Discussion Leader	Registered
<u>FARUQ MARIKAR</u>	SGL CARBON	Attendee	Registered
<u>CHARLES MARTIN</u>	W.L. GORE & ASSOCIATES	Attendee	Registered
<u>REBECCA J MATHEW</u>	UNIVERSITY OF SOUTHAMPTON	Poster Presenter	Registered
<u>JEREMY P MEYERS</u>	BELL LABORATORIES, LUCENT TECHNOLOGIES	Attendee	Registered
<u>WILLIAM MITCHELL</u>	EPYX	Speaker	Registered
<u>ROBERT M MOORE</u>	UNIVERSITY OF CALIFORNIA, DAVIS	Speaker	Registered
<u>YU MORIMOTO</u>	TOYOTA CENTRAL R&D LABS.IN.	Attendee	Registered
<u>SANJEEV MUKERJEE</u>	NORTHEASTERN UNIVERSITY	Speaker	Registered
<u>S R NARAYANAN</u>	NASA - JET PROPULSION LABORATORY	Discussion Leader	Registered
<u>JOHN M NEWTON</u>	NATIONAL POWER PLC	Attendee	Registered
<u>KEN-ICHIRO OTA</u>	YOKOHAMA NATIONAL UNIVERSITY	Poster Presenter	Registered
<u>STEPHEN J PADDISON</u>	LOS ALAMOS NATIONAL LABORATORY	Poster Presenter	Registered
<u>BRANT A PEPPELY</u>	ROYAL MILITARY COLLEGE OF CANADA	Attendee	Registered
<u>MICHEL PINERI</u>	CEA	Speaker	Registered
<u>PETER N PINTAURO</u>	TULANE UNIVERSITY	Speaker	Registered
<u>BRYAN S PIVOVAR</u>	UNIVERSITY OF MINNESOTA	Poster Presenter	Registered
<u>XIAOMING REN</u>	LOS ALAMOS NATIONAL LABORATORY	Poster Presenter	Registered
<u>PHILIP N ROSS</u>	LAWRENCE BERKELEY LABORATORY	Speaker	Registered
<u>ANDREA E RUSSELL</u>	UNIVERSITY OF SOUTHAMPTON	Poster Presenter	Registered
<u>DOMINICK A SAMA</u>	UNIV. OF MASSACHUSETTS LOWELL	Attendee	Registered
<u>STEPHEN R SAMMS</u>	CASE WESTERN RESERVE UNIVERSITY	Attendee	Registered
<u>GISELLE SANDI</u>	ARGONNE NATIONAL LABORATORY	Poster Presenter	Registered
<u>MICHAEL J SANSONE</u>	HOECHST CELANESE CORP	Attendee	Registered
<u>KAZUNORI SATO</u>	NAGAOKA UNIVERSITY OF TECHNOLOGY	Poster Presenter	Registered
<u>ROBERT F SAVINELL</u>	CASE WESTERN RESERVE UNIVERSITY	Discussion Leader	Registered
<u>WERNER F SCHNURNBERGER</u>	GERMAN AEROSPACE CENTER	Speaker	Registered
<u>JAMES P SEABA</u>	HONDA R&D AMERICAS	Attendee	Registered
<u>MORDECAI SHELEF</u>	FORD MOTOR COMPANY	Chair	Registered
<u>SUBHASH C SINGHAL</u>	SIEMENS WESTINGHOUSE POWER CORPORATION	Speaker	Registered
<u>MOSES SORKIN</u>	H POWER CORP	Attendee	Registered
<u>MARGARET M STEINBUGLER</u>	UNITED TECHNOLOGIES RESEARCH CENTER	Attendee	Registered
<u>ULRICH STIMMING</u>	TECHNISCHE UNIVERSITAT MUNCHEN	Speaker	Registered
<u>ERIC M STUVE</u>	UNIVERSITY OF WASHINGTON	Discussion Leader	Registered
<u>WAYNE A SURDOVAL</u>	U.S.DEPARTMENT OF ENERGY/NETL	Attendee	Registered
<u>Craig Thompson</u>	EPYX	Attendee	Registered
<u>ALFRED TSEUNG</u>	UNIVERSITY OF GREENWICH	Attendee	Registered
<u>JOHN A TURNER</u>	NATIONAL RENEWABLE ENERGY LAB	Speaker	Registered
<u>ISAMU UCHIDA</u>	GRAD SCHOOL OF ENG, TOHOKU UNIV	Attendee	Registered
<u>OMO VELEV</u>	AEROVIRONMENT INC	Attendee	Registered
<u>MARKUS R VOGT</u>	DEGUSSA-HUELS AG	Attendee	Registered
<u>SUSANNE VOSS</u>	ICTAS, TU-GRAZ	Poster Presenter	Registered
<u>MANFRED F WAIHDAS</u>	SIEMENS AG	Speaker	Registered

<u>MARLON L WALKER</u>	OFFICE OF NAVAL RESEARCH	Attendee	Registered
<u>MASAHIRO WATANABE</u>	YAMANASHI UNIVERSITY	Speaker	Registered
<u>DACONG WENG</u>	ALLIEDSIGNAL INC	Attendee	Registered
<u>ANDRZEJ WIECKOWSKI</u>	UNIVERSITY OF ILLINOIS	Speaker	Registered
<u>WAYNE L WORRELL</u>	UNIVERSITY OF PENNSYLVANIA	Speaker	Registered
<u>JAMES T YANG</u>	INTERNATIONAL FUEL CELLS	Attendee	Registered
<u>TAKESHI YAO</u>	KYOTO UNIVERSITY	Poster Presenter	Registered
<u>JUNG S YI</u>	INTERNATIONAL FUEL CELLS	Attendee	Registered
<u>THOMAS A ZAWODZINSKI</u>	LOS ALAMOS NATIONAL LAB	Speaker	Registered



